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(54) CLEANING OF PIECE PARTS BY THE USE OF A FLUIDIZED-SOLIDS BED

(71) We, PROCEDYNE CORPORATION of 221 Somerset Street, New Brunswick, New Jersey 08903, United States of America; a corporation organized and existing under the laws of the State of New York, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method may which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to a method of utilizing a heated fluidized solids bed for cleaning machine and other piece parts which have a surface contamination of organic material, such as resins or fibrous materials. The parts are submerged in the bed and the bed is heated to a temperature level at which the predominant reactions of the contaminating substances are pyrolytic with substantially little combustion, thereby protecting the surface of the parts from thermal damage. The particles comprising the bed are agitated by passing gas therethrough to achieve, temperature uniformity to pyrolyze and dislodge the contaminants. An upper or vapor space is provided above the bed, into which steam or inert gas may be supplied to avoid ignition of the contaminants above the bed since this may cause conduction of heat back into the bed resulting in overheating of the parts and possible thermal damage thereto. Predominantly pyrolytic reactions are achieved by regulating the temperature level of the bed and controlling the rate of flow of oxygen thereto.

So called fluidized-solids beds are well-known, one field of application being the calibration of thermometers, thermocouples and other temperature-sensing devices, another field of application being the decoating of films on metal substrates by incineration in a fluidized bed as disclosed in U.S. Patent No. 3,250,643.

If a vessel containing finely divided inert particles, such as sand, aluminium oxide and similar refractory materials, is constructed so that a gas (e.g. air, steam or nitrogen) can be passed through the "bed" of particles, a state can be achieved, called "fluidization", in which the individual particles become microscopically separated from each other by the moving gas. This "fluidized bed" of particles has unusual properties which differ from those of either the gas or the particles. Instead, the fluidized bed behaves remarkably like a liquid, exhibiting characteristics which are generally attributable to a liquid state. For example, the fluidized bed can be agitated and bubbled; it always seeks a common level; materials that are of light density will float while those with densities greater than the equivalent fluidized bed density will sink and, most important, the heat transfer characteristics between the fluidized bed and a solid interface can have an efficiency approaching that of an agitated liquid.

The most commonly used fluidizing gas is ordinary compressed air obtained from a blower or compressor. For situations where a non-oxidizing atmosphere is required, nitrogen can be utilized and, if a reducing atmosphere is required, steam or cracked gas can be employed with a silicon carbide bed.

The unique characteristic of gas-fluidized solids is the relatively high rate of heat transfer within the phase which yields highly isothermal conditions, as well as excellent heat transfer to solid surfaces submerged in the phase. This characteristic is due to the turbulent motion and rapid circulation rate of the solid particles in conjunction with the extremely high, solid-gas interfacial area. Therefore, despite the fact that gas-solid interfaces normally used have low thermal conductivities, the overall heat transfer characteristics of a fluidized solids phase approach those of a liquid.

This combination of excellent heat transfer characteristic and high heat capacity make fluidized solids an excellent medium for providing an isothermal environment for performing chemical reactions such as pyrolysis, defined as the thermal decomposition of organic materials in the absence of oxygen (typically endothermic), or combustion defined as the oxidation of materials (typically exothermic) in the presence of oxygen. These reactions are typified by:

$$\left[\begin{matrix}H\\ -C-\\ H\end{matrix}\right]_x \xrightarrow[\text{(endothermic-heat uptake)}]{} C + CH_4 + \text{etc.}$$

AND

$$\left[\begin{matrix}H\\ -C-\\ H\end{matrix}\right]_x + 3/2\ O_2 \xrightarrow[\text{(exothermic-heat release)}]{} CO_2 + H_2O$$

In the application of fluidized beds to decoating as described in the aforementioned United States patent, a combustible coating is incinerated or combusted in a fluidized bed. The air in the bed provides the oxygen required to support combustion. When the general approach of the prior art patent is followed in an attempt to recover parts which have a substantial amount of polymeric substance present rather than a thin film as is generally encountered in decoating, and it is important to avoid thermal damage or dimensional distortion to the surface of the part, so as to preserve the value of the part for reclamation, the process of incineration is usually unsatisfactory. This is beause too much heat is released during the treatment which causes the temperature of the part being treated to rise to a level at which the part becomes damaged. Typical cleaning applications therefore require the temperature to be limited to below 850°F. It is then necessary to maintain an environment deficient in oxygen to encourage thermal decomposition by pyrolysis type reactions which take up heat (endothermic), and to minimize combustion type reactions which release heat (exothermic). Pyrolysis of organic substances proceeds at substantial rates in the temperature range of 750° to 900°F.

Where, in this specification, we employ the term "predominantly pyrolytic reactions" or equivalent language, it is intended that the ideal goal sought in the operation of a bed in accordance with the principles of the invention be a pyrolytic reaction, i.e. avoidance of combustion-type reactions, and that any flow of oxygen to the bed be controlled to achieve that object. In practice, an automatic flow regulator is employed. However, due to the inherent factors determining performance of the regulating means, it may be expected that pyrolytic conditions can not be perfectly maintained. The terms "predominantly" or "predominant" have been employed in order that the claims not be given an interpretation that perfection in achieving the desired pyrolytic reaction is an absolute necessity.

When pyrolytic reactions are predominant, the gases leaving the fluidized bed are only partially oxidized and are therefore flammable. In contact with air above the bed, these gases usually ignite, causing back condution of heat into the bed with the result that the parts being reclaimed are overheated. In addition, this condition can cause hazards to personnel and equipment.

Typical requirements for recovering useful substrates with large organic contamination include the recovery of machine parts such as molds used in the fabrication of plastic compositions, drawing and extruding dies, metal parts having molded plastic portions such as the recovery of the metal portion of automobile headrests, dashboards, and bumpers from imperfect or damaged plastic sections and, in general, parts where preservation of dimensions is a primary desideratum.

This invention seeks to provide a process which permits reclamation of many useful parts without thermal damage to the surface thereof and thermal distortion dimensionally occurring.

In accordance with the invention, there is provided a method of stripping deposits of unwanted pyrolyzable matter from a piece part without degrading the piece part comprising the steps of providing a vessel containing a mass of refractory particles, said mass having a volume less than the interior volume of the vessel so as to define a space between the mass and the top portion of the vessel, applying heat and gas under pressure to the mass to fluidize the particles, submerging at least that portion of the piece part having the unwanted matter deposited thereon in the fluidized mass and, whilst the piece part is submerged, regulating the temperature at which the bed is operated by controlling the heat supplied to the bed and controlling the availability of oxygen to the bed so as to promote pyrolytic reactions between the unwanted matter and the oxygen and to minimize combustion

reactions therebetween. Preferably, the process comprises the additional steps of providing an exit vent in communication with the space, exhausting the off-gas from the bed through the vent and, concurrently with the exhaust of the off-gas, delivering a blanketing medium to the space to prevent the tendency of the off-gas to ignite and back-conduct heat into the bed. The choice of size of particulate solids and the gas (usually air) is made to ensure a relatively low availability of oxygen in the vicinity of the parts being cleaned. Typically, the use of 150 mesh solids such as Al_2O_3 (aluminium oxide) accomplishes this environment. However, various fluidizing media may be employed, e.g. air, oxygen, or nitrogen alone, or admixtures thereof. The solids can be sand or other inert particulates.

In addition to the emphasis on pyrolysis to limit the heat released by the reaction, the fluidized solids bed has high heat capacity and high heat transfer rate characteristics which distribute the limited heat released throughout the bed and provide uniform temperature throughout the bed and minimize the formation of localized high temperature areas on the piece part. Thus, the possibility of distortion or destruction of the part is precluded.

Since the temperature of a fluidized solids bed can be controlled quite precisely by controlling the heat supplied to the bed, typically less than ± 1°F., the contaminant can be removed at a temperature which is predetermined to result in maximum efficiency.

A major problem associated with this type of cleaning process, and one to which the present invention is directed, is the handling of flammable gases leaving the bed and preventing ignition above the bed.

This ignition over the bed can cause the bed itself to overheat, due to back-conduction and radiation of heat from the flame down into the bed. Such malfunction is generally regarded as undesirable since it usually causes over-temperature of the bed with thermal damage to the parts being reclaimed and can cause a flash into the exhaust system with resultant hazards to personnel and equipment.

To neutralize this malfunction, the present invention also comprehends the metering of steam, water or inert gas into the space above the bed at a rate calculated to dilute the concentration of flammable products and/or the oxygen level.

A typical example of this invention involves the reclamation of an automobile head rest part when an imperfect polyurethane cushion has been molded therein. The objective is to economically remove the imperfect cushion while preserving the value of the part itself for reuse.

A typical part weighs 2.44 lbs. containing approximately 0.28 lbs. of polyurethane foam. These parts are successfully reclaimed by the use of this invention at 850°F, a bed of 150 mesh Al_2O_3 and limited fluidizing air. Sufficient steam is injected into the space above the bed to reduce the composition of flammable gases below 0.03 mole per cent.

The invention will be further described, by way of example, with reference to the accompanying drawing, the single figure of which shows a front elevation partially in section, of an apparatus suitable for carrying out the method of the present invention.

In the drawing, there is shown a vessel 10 having a funnel-shaped bottom portion 11 defining, in part, a chamber 10*a* in communication with a pipe 12. Supported in any suitable manner above the chamber 10*a* is a gas-permeable disc 15 which may be formed of porous ceramic material, or may be a perforated plate or other member capable of passing the gas whilst simultaneously being capable of supporting particulate material constituting the fluidized bed 16. The disc 15 is resistant to breakdown at the operating temperature of the bed.

The bed comprises refractory particles of sand or aluminium oxide having a mesh size calculated to allow intimate contact of the particles with the smallest openings and recesses of a piece undergoing treatment in the apparatus.

The vessel 10 has a cover 19 which is suitably secured thereto which, together with the bed 16, defines an upper space 21. The bed 16 is heated by any suitable means such as a sheathed electrical heating element 22 coiled intimately around the vessel 10.

In order to render the apparatus more versatile, means are provided to feed either air or a gas other than air, such as nitrogen, to the bed. Thus inlet pipes 12*a* and 12*b* merge into the pipe 12. Each of the pipes 12*a* and 12*b* has a conventional flow control valve 25*a*, 25*b* and on-off valves 26*a*, 26*b*. These latter are used to isolate the selected line 12*a* or 12*b* from the unused line.

Means are provided for supplying an aqueous medium such as steam or water, or an inert gas, to the space 21 to smother potentially ignitable gases. Such means comprises a supply pipe 41 equipped with a flow meter 42 and a throttling valve 43. The pipe 41 terminates within the upper space 21 and is capped by a spray nozzle 54 or equivalent distributor designed to distribute the smothering medium.

When water is fed through the pipe 41, it is converted into steam in the space 21. When, using an alternative procedure, steam or inert gas is fed, less power is required by the system. In either case, water or inert gas is present in the off-gas discharged through duct

48, which dilutes the concentration of other gases contained therein, and maintains the concentration of flammable products below the lower flammable or explosive limits. The flow of off-gas from the surface of the bed via the duct 48 prevents steam or inert gas from entering the bed and contacting the parts being cleaned. Thus, corrosion of the parts is precluded.

As is apparent from the drawing, the piece parts to be cleaned, one of which is shown at *P* may be supported in the bed by any convenient means, such as by a wire *W*. The parts will be subjected to the action of the heated particles of the bed which provide, so to speak, a heat transfer medium for heating the part to temperatures for decomposition of the polymeric unwanted matter and distributing any heat of reaction throughout the bed to maintain temperature uniformity. The relative rates of pyrolysis and combustion reactions and rates of heat transfer to and from the piece parts may be readily moderated by adjustment of gas flow through the inlet pipe 12. By so doing it is possible to increase or decrease both the availability of oxygen and the physical mobility of the bed. This permits removal of the unwanted polymeric matter at a uniform temperature without thermal damage to the parts being reclaimed.

WHAT WE CLAIM IS:-

1. A method of stripping deposits of unwanted pyrolyzable matter from a piece part without degrading the piece part comprising the steps of providing a vessel containing a mass of refractory particles, said mass having a volume less than the interior volume of the vessel so as to define a space between the mass and the top portion of the vessel, applying heat and gas under pressure to the mass to fluidize the particles, submerging at least that portion of the piece part having the unwanted matter deposited thereon in the fluidized mass and, whilst the piece part is submerged, regulating the temperature at which the bed is operated by controlling the heat supplied to the bed and controlling the availability of oxygen to the bed so as to promote pyrolytic reactions between the unwanted matter and the oxygen and to minimize combustion reactions therebetween.

2. A method as claimed in claim 1 comprising the additional steps of providing an exit vent in communication with the space, exhausting the off-gas from the bed through the vent and, concurrently with the exhaust of the off-gas, delivering a blanketing medium to the space to prevent the tendency of the off-gas to ignite and back-conduct heat into the bed.

3. A method as claimed in claim 2 wherein the blanketing medium is an aqueous medium.

4. A method as claimed in claim 2 wherein the blanketing medium is a gaseous medium.

5. A method as claimed in any preceding claim in which the temperature of the bed is maintained at a temperature of substantially 850°F.

6. A method as claimed in claim 1 substantially as hereinbefore described.

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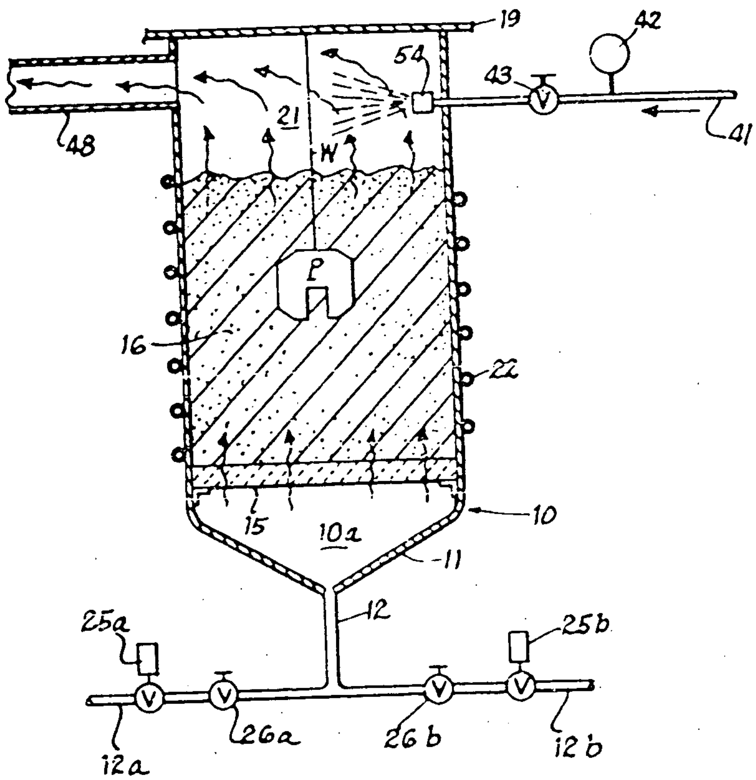
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